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THEORETICAL APPROACH ON THE NITROGEN POTENTIAL CONTRIBUTION FROM SUSTAINABLE NATURAL FERTILIZATION WITH CATTLE MANURE

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Abstract

The paper aimed to present a theoretical approach on the nitrogen potential contribution of the cattle manure for natural and sustainable soil fertilization, on different development regions of Romania, during 2017-2021. Calculations are based on statistical data provided by Ministry of Agriculture and Rural Development and National Institute of Statistics. Taking into account the maximum amount of nitrogen of 170 kg/ha that can be administered, the share of the nitrogen coverage potential from cattle manure was determined for each development region and for the different crops. The results showed that the amounts of nutrients from cattle manure could cover different shares for different crops, and for many of them, even 100%, like legumes, or potatoes, or vegetables, or orchards for fruit. The sustainable fertilization of the cattle manure represents a valuable argument for the importance of this species – bovine, in the present opinion exchanges.

Key words**:** *nitrogen, cattle, fertilization, crops, sustainability*

INTRODUCTION

The manure is one of the most used organic fertilizers, due to its availability [9], but also the manure application may improve sustainable soil productivity and crop yield, soil organic carbon, available nitrogen, phosphorus and potassium, and the abundances of bacteria [2].

According to [12, 13], fertilization of crops with organic manure has important effects on chemical and biological soil properties.

The use of chemical fertilizers in agriculture has increased concerns for the soil fertility, so that, natural inputs are required to ensure that intensive productions do not affect the sustainability of the soil [4, 7].

Also, the animal manure can be a valuable source of resources into a circular concept [6].

Animal manure is widely used to provide additional organic matter for improving soil structure and nutrients for crop growth [5].

Improving the soil quality for increasing the agricultural sustainability means the use of organic amendment through the addition of manure [3].

The utilization management of livestock manure is considered an important way to avoid environmental pollution in animal farms [8]. The European legislation has regulated the use of animal manure, referring to human health, preserving environmental quality, and the equilibration of the dairy markets [14].

The application of manure provides benefits like better crop productivity, improved organic matter, reduced soil erosion, improves soil water availability [1].

In this context, the purpose of this research is to analyze the nitrogen potential contribution of the cattle manure for natural and sustainable soil fertilization, in different development regions of Romania, during 2017-2021, using the statistical data provided by Ministry of Agriculture and Rural Development and National Institute of Statistics.

MATERIALS AND METHODS

In order to estimate the nitrogen potential contribution of the cattle manure for natural soil fertilization, available data from the Ministry of Agriculture and Rural Development and national official statistics were used: quantities of manure produced from different categories of cattle, on development regions, during 2017-2021, areas cultivated

with different crops, on development regions, the cattle manure content in nutrients and the maximum quantity of nitrogen per hectare that can be administered.
The methods used in this research have been: dynamic analysis, fixed basis indices, structural indices, regression functions, R square, graphical design and comparison method.

RESULTS AND DISCUSSIONS

Calculations based on operative data from Ministry of Agriculture and Rural Development from 2021 indicate the structure of manure, by species (Table 1), in which cattle manure has the largest share, of 35.45%, followed by poultry with 22.20% and sheep and goats with 20.96%.

Table 1. The structure of manure, by species

Species	Quantity, tons	Share, %
Cattle	15,329,744	35.45
Horses	2,180,736	5.04
Poultry	9,599,152	22.20
Sheep and goats	9,063,451	20.96
Pigs	7,069,252	16.35
Total	**43,242,335**	**100.00**

Source: Own calculations based on operative data from MARD [10].

Center Region

In the Center Region, the amount of cattle manure produced in during 2017-2021 had an oscillating course, increasing slightly by 2.25% (Figure 1).

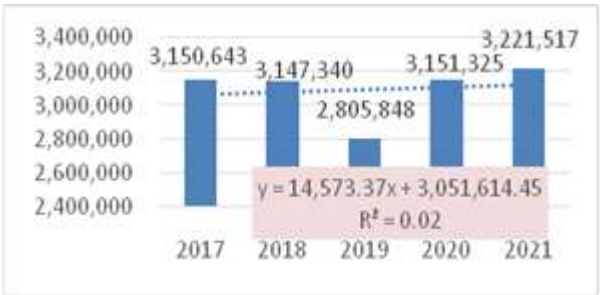

Fig. 1. The evolution of cattle manure production in the Center Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

The provenance structure of manure, by category of cattle, in 2017, was 76.89% from cows, 13.02% from young cattle over 1 year, 9.81% from young cattle under 1 year and only 0.28% from oxen.

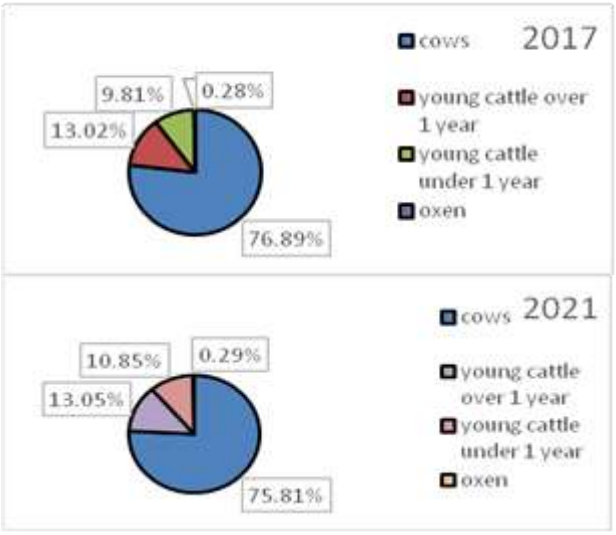

Fig. 2. The provenance structure of cattle manure in the Center Region
Source: Own calculations and graphing following MARD operational data [10].

This structure changed slightly in 2021, in the sense of a decrease in the share of the quantities coming from cows (75.81%), respectively an increase in the share of the other categories (Figure 2).
Consequently, the nutrient production from cattle manure increased by 2.25%, mentioning nitrogen, from 14,178 tons to 14,497 tons (Figure 3).

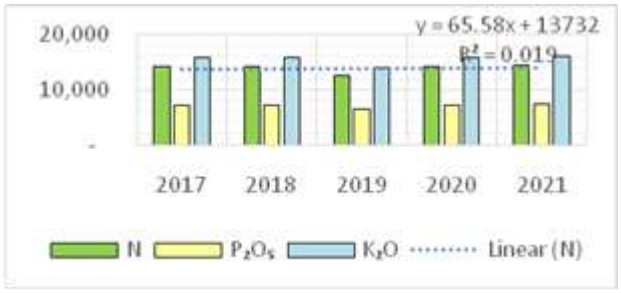

Fig. 3. The evolution of nutrient production from cattle manure in the Center Region (tons)
Source: Own calculations.

According to data in Table 2, the area cultivated in Center Region was 574.0 thousand ha in 2017, decreasing to 561.6 thousand ha in 2021 (-2.1%). Of this, 54.8% was occupied by cereals, followed by green fodder from arable land (28.7%-30.3%).
Taking into account the maximum amount of nitrogen of 170 kg/ha that can be administered,

the share of the nitrogen coverage potential from cattle manure was determined, which varied between 14.5% in 2017 and 15.18% in 2021, for the total cultivated areas in the Center Region.

For the areas cultivated with cereals, the fertilization potential with cattle manure was between 26.9% in 2017 and 27.70% in the year 2021. Another variant consisted in fertilizing the areas with green fodder from arable land, which could be naturally fertilized up to 47.9% in 2017, respectively up to 52.76% in 2021.

Table 2. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the Center Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	574,039	14.5	585,866	14.22	576,947	12.87	558,595	14.93	561,626	15.18
Cereals	310,453	26.9	313,907	26.54	311,774	23.82	305,555	27.30	307,811	27.70
Legumes	1,706	>100.0	1,487	>100.0	1,296	>100.0	1,283	>100.0	960	>100.0
Textile plants	471	>100.0	222	>100.0	493	>100.0	575	>100.0	692	>100.0
Oily plants	29,956	>100.0	33,094	>100.0	35,139	>100.0	38,660	>100.0	42,702	>100.0
Medicinal and aromatic plants	115	>100.0	173	>100.0	182	>100.0	192	>100.0	210	>100.0
Potatoes - total	35,667	>100.0	36,048	>100.0	35,977	>100.0	25,029	>100.0	30,141	>100.0
Vegetables - total	18,502	>100.0	18,703	>100.0	18,561	>100.0	16,139	>100.0	16,410	>100.0
Green forages from arable land	174,025	47.9	178,109	46.78	170,067	43.67	168,376	49.54	161,618	52.76
Fodder roots	1,076	>100.0	958	>100.0	1,052	>100.0	1,541	>100.0	655	100.0
Flowers and ornamental plants	77	>100.0	79	>100.0	105	>100.0	76	>100.0	92	>100.0
Orchards	7,827	>100.0	7,719	>100.0	7,643	>100.0	7,355	>100.0	7,604	>100.0
Surface of the greenhouses	10	>100.0	9	>100.0	10	>100.0	11	>100.0	5	>100.0
Arable land not cultivated	48,045	>100.0	47,665	>100.0	47,646	>100.0	46,941	>100.0	38,021	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

The other crops, separately, like legumes, textile plants, oily plants, medicinal and aromatic plants, potatoes, vegetables, fodder roots, flowers and ornamental plants, orchards, greenhouses would be 100% and over, covered by the nitrogen from cattle manure.

West Region

In the West Region, in the time interval 2017-2021, the amount of manure produced by cattle decreased by 26,971 tons per year, respectively by 5.57% during the periodstudied, following an oscillating trend (Figure 4). In this region, in 2017, the provenance structure of manure, by category of cattle, was 76.63% from cows, 14.5% from young cattle over 1 year, 8.69% from young cattle under 1 year and 0.18% from oxen. In 2021, the share of the manure produced by cows increased, up to 79.38% (+2.75%) (Figure 5).

Fig. 4. The evolution of cattle manure production in the West Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

According to Figure 6, the nutrient productions also decreased by 5.5% over the analyzed period, nitrogen reaching from 6,270 tons in 2017, to 5,920 tons in 2021.

The area cultivated in the West Region decreased in 2021 by 19.1% compared to 2017, reaching 769.5 thousand hectares, of which 505.4 thousand hectares were cultivated with cereals (65.6%) (Table 3).

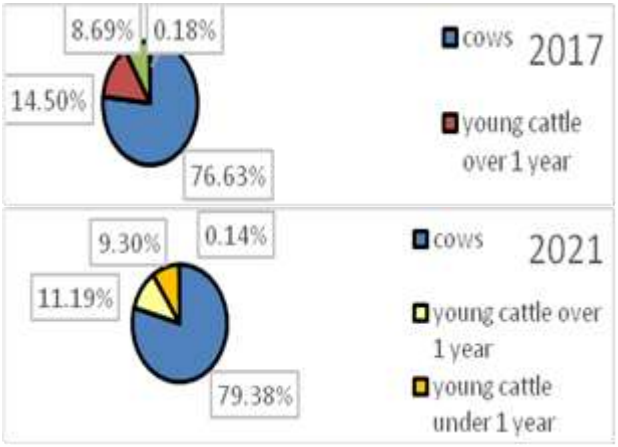

Fig. 5. The provenance structure of cattle manure in the West Region
Source: Own calculations and graphing following MARD operational data [10].

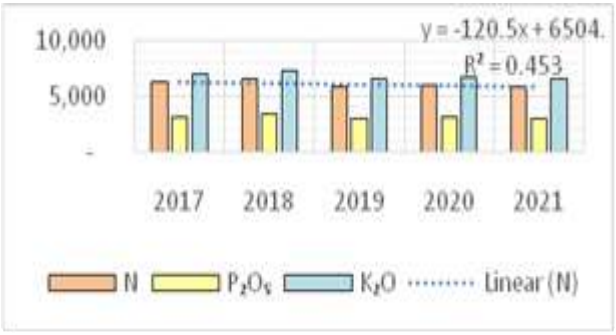

Fig. 6. The evolution of nutrient production from cattle manure in the West Region (tons)
Source: Own calculations.

Table 3. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the West Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	951,684	3.88	979,204	3.95	1,155,731	3.00	844,476	4.22	769,508	4.53
Cereals	613,325	6.01	613,607	6.30	768,741	4.50	541,104	6.59	505,430	6.89
Legumes	1,995	>100.0	3,407	>100.0	1,666	>100.0	2,907	>100.0	1,578	>100.0
Textile plants	215	>100.0	0	0	98	>100.0	0	0	5	>100.0
Oily plants	207,888	17.74	229,336	16.85	246,203	14.07	185,963	19.18	144,949	24.03
Medicinal and aromatic plants	117	>100.0	24	>100.0	36	>100.0	30	>100.0	30	>100.0
Potatoes - total	16,963	>100.0	16,938	>100.0	16,902	>100.0	9,080	>100.0	7,129	>100.0
Vegetables - total	28,493	>100.0	28,599	>100.0	28,816	>100.0	29,275	>100.0	23,367	>100.0
Green forages from arable land	85,616	43.08	93,189	41.48	100,775	34.36	85,272	41.83	94,397	36.89
Fodder roots	1,411	>100.0	1,289	>100.0	1,363	>100.0	1,290	>100.0	669	>100.0
Flowers and ornamental plants	10	>100.0	8	>100.0	8	>100.0	7	>100.0	11	>100.0
Orchards	11,590	>100.0	11,304	>100.0	11,530	>100.0	11,351	>100.0	11,675	>100.0
Surface of the greenhouses	32	>100.0	22	>100.0	21	>100.0	8	>100.0	18	>100.0
Arable land not cultivated	83,431	44.20	90,575	42.68	98,462	35.17	93,376	38.20	81,129	42.93

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

According to the maximum amount of nitrogen of 170 kg/ha, the nitrogen coverage potential of cattle manure in the West Region, on total cultivated area, was between 3.88% in 2017 and 4.53% in 2021.
The amount produced had a coverage potential of between 6.01% - 6.89% for the cereal area in the region, or 17.74% - 24.03% for oilseeds, or 34.36% - 43.08 % for green fodder from arable land, or 100% for vegetables.

South-MunteniaRegion

During the analyzed period, in the South-Muntenia Region, the amount of cattle manure decreased continuously, by 104,201 tons per year, respectively by 21.8% during the studied period (Figure 7).

Fig. 7. The evolution of cattle manure production in the South-Muntenia Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

Of the total cattle manure produced in 2017, 77.98% was from the cow category and increased to 80.25% in 2021, the rest being from the other categories, according to Figure 8.

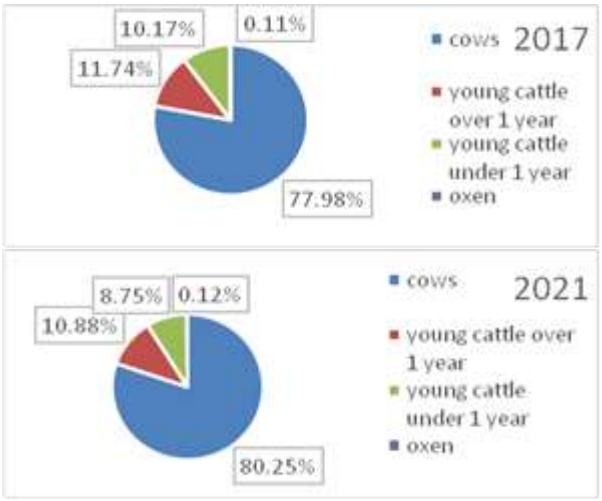

Fig. 8. The provenance structure of cattle manure in the South-Muntenia Region
Source: Own calculations and graphing following MARD operational data [10].

In this interval, the amounts of nutrients produced, having the cattle manure as a source, decreased by 21.8%, as follows: nitrogen from 8,341 tons to 6,521 tons (by 468.9 tons/year), phosphorus from 4,263 tons to 3,333 tons, and potash from 9,268 tons to 7,245 tons (Figure 9).

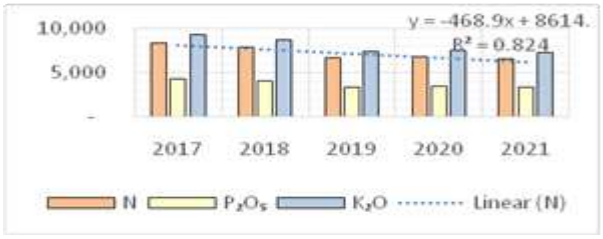

Fig. 9. The evolution of nutrient production from cattle manure in the South-Muntenia Region (tons)
Source: Own calculations.

In the South-Muntenia Region, the areacultivated was 1.86 million hectares in 2017 and decreased to 1.83 million hectares in 2021 (-1.6%) (Table 4). Here too, the largest share is held by the areas cultivated with cereals (63.9%), followed by those with oil plants (26.1%).

Table 4. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the South-Muntenia Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	1,864,136	2.63	1,870,788	2.45	1,891,769	2.06	1,849,701	2.15	1,832,684	2.09
Cereals	1,191,855	4.12	1,189,048	3.86	1,277,791	3.05	1,296,492	3.07	1,249,906	3.07
Legumes	38,161	>100.0	40,512	>100.0	35,577	>100.0	26,562	>100.0	18,490	>100.0
Textile plants	8	>100.0	40	>100.0	12	>100.0	14	>100.0	16	>100.0
Oily plants	487,323	10.07	500,670	9.17	431,177	9.02	391,388	10.16	439,539	8.73
Medicinal and aromatic plants	606	>100.0	381	>100.0	194	>100.0	212	>100.0	354	>100.0
Potatoes - total	16,599	>100.0	16,576	>100.0	16,597	>100.0	10,309	>100.0	6,903	>100.0
Vegetables - total	41,157	>100.0	41,327	>100.0	43,430	89.59	33,600	>100.0	35,632	>100.0
Green forages from arable land	104,813	46.81	97,697	47.00	105,138	37.01	104,526	38.03	97,365	39.39
Fodder roots	724	>100.0	684	>100.0	681	>100.0	669	>100.0	569	>100.0
Flowers and ornamental plants	54	>100.0	57	>100.0	54	>100.0	55	>100.0	56	>100.0
Orchards	40,349	>100.0	39,613	>100.0	38,942	99.92	39,967	99.45	39,679	96.67
Surface of the greenhouses	42	>100.0	44	>100.0	40	>100.0	38	>100.0	23	>100.0
Arable land not cultivated	10,510	>100.0	13,077	>100.0	11,065	>100.0	11,069	>100.0	17,679	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

Considering the areas cultivated in the South-Muntenia Region, shown in Table 4, the share of the nitrogen coverage potential from the cattle manure produced in the region was between 2.63% in 2017 and 2.09% in 2021. However, for example, the areas cultivated with legumes, or with vegetables, or with orchards could be completely fertilized.

North-East Region

In the North-East Region, between 2017 and 2021, cattle manure production decreased by 14.8%, falling by 159,017 tonnes per year to 3.38 million tonnes (Figure 10).

Fig. 10. The evolution of cattle manure production in the North-East Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

The origin structure of the manure indicates that it was produced in a proportion of 74.47% by the category of cows in 2017, respectively 75.41% in 2021, the rest being from young cattle and oxen (Figure 11). Consecutively, the amounts of nutrients decreased, from 17,844 tons of nitrogen to 15,202 tons (-795.1 tons/year), phosphorus from 9,120 tons to 7,770 tons, potassium from 19,827 tons to 16,891 tons (Figure 12). The area cultivated in the North-East Region was 1.28 million hectares in 2021, 9.2% more extensive than in 2017 (Table 5).

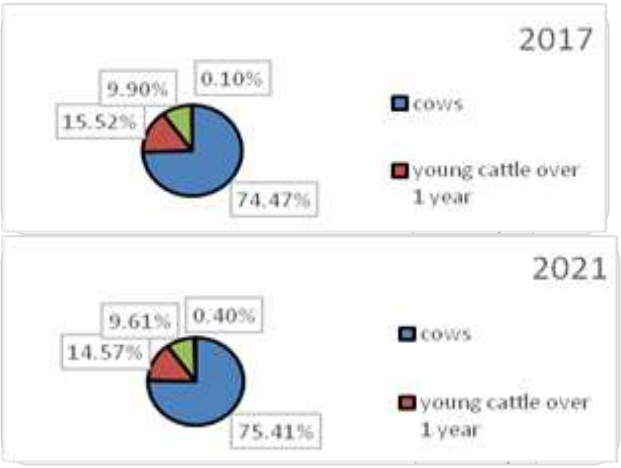

Fig. 11. The provenance structure of cattle manure in the North-East Region
Source: Own calculations and graphing following MARD operational data [10].

Fig. 12. The evolution of nutrient production from cattle manure in the North-East Region (tons)
Source: Own calculations.

Table 5. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the North-East Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	1,175,107	8.93	1,207,636	8.55	1,275,621	6.95	1,256,264	7.35	1,283,145	6.97
Cereals	665,108	15.78	683,539	15.11	696,491	12.73	700,952	13.17	759,005	11.78
Legumes	9,435	>100.0	11,452	>100.0	7,720	>100.0	6,158	>100.0	7,327	>100.0
Textile plants	621	>100.0	962	>100.0	559	>100.0	387	>100.0	12	>100.0
Oily plants	210,775	49.80	213,751	48.33	271,351	32.66	273,689	33.72	250,976	35.63
Medicinal and aromatic plants	126	>100.0	61	>100.0	70	>100.0	78	>100.0	152	>100.0
Potatoes - total	42,413	>100.0	43,776	>100.0	44,522	>100.0	25,199	>100.0	22,366	>100.0
Vegetables - total	40,212	>100.0	42,330	>100.0	42,526	>100.0	37,249	>100.0	39,452	>100.0
Green forages from arable land	208,030	50.46	213,634	48.35	213,092	41.59	213,148	43.30	206,815	43.24
Fodder roots	3,942	>100.0	3,928	>100.0	3,752	>100.0	3,346	>100.0	2,446	>100.0
Flowers and ornamental plants	28	>100.0	30	>100.0	27	>100.0	19	>100.0	15	>100.0
Orchards	12,035	>100.0	13,474	>100.0	11,930	>100.0	11,920	>100.0	13,254	>100.0
Surface of the greenhouses	13	>100.0	7	>100.0	5	>100.0	5	>100.0	:	:
Arable land not cultivated	4,790	>100.0	3,938	>100.0	4,025	>100.0	3,918	>100.0	2,158	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure.

Of this area, 59.2% was cultivated with cereals, on second place being the one with oil plants (19.6%). The nitrogen coverage potential from cattle manure was 8.93% in 2017, respectively 6.97% in 2021, for the entire cultivated area of the North-East Region. Other variants of such

natural fertilization were total coverage of the areas cultivated with potatoes or those with vegetables.

North-West Region

In the North-West Region, in 2017, 2,976.5 thousand tons of cattle manure were produced, and in 2021, by 6% more, respectively 3,156.3 thousand tons (Figure 13).

Fig. 13. The evolution of cattle manure production in the North-West Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

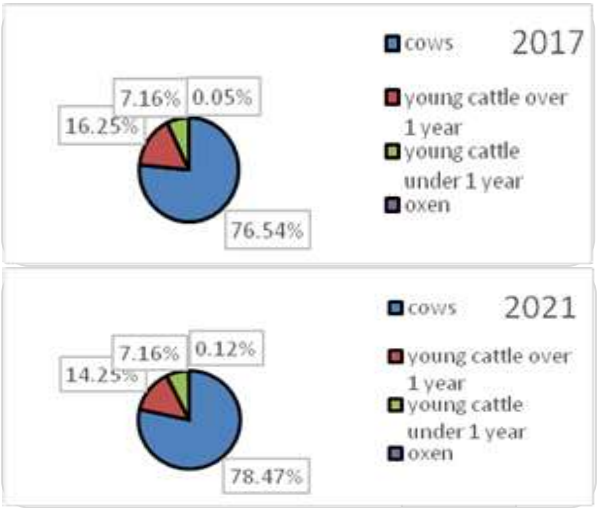

Fig. 14. The provenance structure of cattle manure in the North-West Region
Source: Own calculations and graphing following MARD operational data [10].

The share of the category of cows, as the main source of manure, increased from 76.54% to 78.47% (Figure 14).

In this region, the production of nutrients, during the period 2017-2021, followed an increasing curve, by 6% per interval, the amount of nitrogen increasing annually by 155.4 tons and reaching 14.2 thousand tons in 2021 (Figure 15).

The area cultivated in the North-West Region was 838.8 thousand hectares in 2021, meaning by 5.4% higher than in 2017 (Table 6).

Fig. 15. The evolution of nutrient production from cattle manure in the North-West Region (tons)
Source: Own calculations.

Almost 60% of the area is cultivated with cereals.

Starting from the cultivated area in this region, the nitrogen coverage potential from cattle manure was 9.9% in 2017 and 9.96% in 2021, respectively, for total cultivated area.

This means that it was registered a slight increase but of less importance, becuase th cultivated area is very large and demand of nitrogen could be higher than it is applied.

Other options: 16-16.65% of areas with cereals, or full fertilization for areas with potatoes or vegetables.

Table 6. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the North-West Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	795,602	9.90	830,310	9.84	841,476	8.87	827,392	9.83	838,819	9.96
Cereals	492,397	16.00	504,764	16.18	504,988	14.78	500,350	16.25	501,819	16.65
Legumes	2,225	>100.0	2,429	>100.0	2,705	>100.0	3,168	>100.0	2,756	>100.0
Textile plants	213	>100.0	215	>100.0	212	>100.0	212	>100.0	:	:
Oily plants	93,578	84.20	100,652	81.14	124,652	59.89	131,058	62.03	145,083	57.59
Medicinal and aromatic plants	481	>100.0	317	>100.0	310	>100.0	314	>100.0	237	>100.0
Potatoes - total	37,657	>100.0	37,320	>100.0	37,508	>100.0	18,582	>100.0	13,896	>100.0
Vegetables - total	22,736	>100.0	22,994	>100.0	22,909	>100.0	21,420	>100.0	21,342	>100.0
Green forages from arable land	147,832	53.30	165,298	49.41	152,591	48.93	156,769	51.85	159,511	52.38
Fodder roots	2,522	>100.0	2,488	>100.0	2,485	>100.0	2,567	>100.0	1,331	>100.0
Flowers and ornamental plants	32	>100.0	33	>100.0	31	>100.0	33	>100.0	70	>100.0
Orchards	25,603	>100.0	24,264	>100.0	24,306	>100.0	24,454	>100.0	26,147	>100.0
Surface of the greenhouses	7	>100.0	8	>100.0	10	>100.0	10	>100.0	6	>100.0
Arable land not cultivated	62,244	>100.0	41,202	>100.0	42,126	>100.0	41,610	>100.0	35,046	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

South-East Region

According to data illustrated in Figure 16, in the South-East Region, in 2017, 1.9 million tons of cattle manure were produced, respectively 1.72 million tons in 2021 (-10%).

Fig. 16. The evolution of cattle manure production in the South-East Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

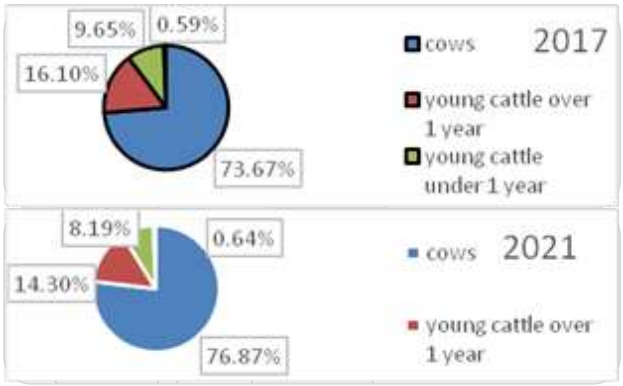

Fig. 17. The provenance structure of cattle manure in the South-East Region
Source: Own calculations and graphing following MARD operational data [10].

The main source of manure was represented by the category of cows, whose share accounted for - 73.67% in 2017, respectively for 76.87% in 2021 (Figure 17).

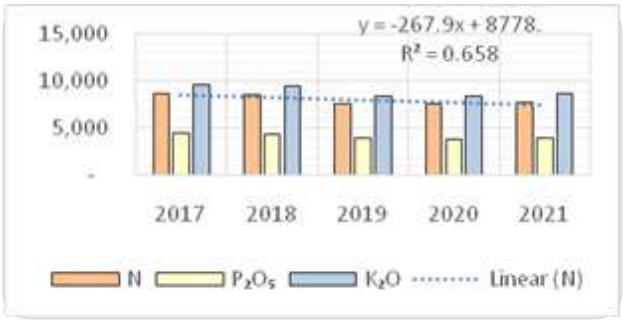

Fig. 18. The evolution of nutrient production from cattle manure in the South-East Region (tons)
Source: Own calculations.

In this region, the area cultivated was 1.77 million hectares in 2021, only 1.3% higher than in 2017 (Table 7), with cereals taking first place, occupying 67.9% of the area. The amount of nutrients from the cattle manure produced here could have completely fertilized (100% of the area) in this region, for example, the areas cultivated with vegetables, or those with fruit orchards, not to mention that of the greenhouses.

Table 7. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the South-East Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	1,746,723	2.89	1,781,171	2.80	1,745,808	2.55	1,712,153	2.58	1,770,974	2.57
Cereals	1,068,340	4.73	1,096,077	4.55	1,139,603	3.90	1,119,979	3.94	1,203,778	3.78
Legumes	44,344	>100.0	49,600	>100.0	46,724	95.13	42,004	>100.0	33,395	>100.0
Textile plants	160	>100.0	49	>100.0	60	>100.0	27	>100.0	5	>100.0
Oily plants	504,570	10.02	505,012	9.88	429,548	10.35	428,035	10.31	407,987	11.17
Medicinal and aromatic plants	1,689	>100.0	781	>100.0	893	>100.0	878	>100.0	1,210	>100.0
Potatoes - total	5,925	>100.0	5,949	>100.0	5,856	>100.0	2,840	>100.0	927	>100.0
Vegetables - total	32,474	>100.0	31,937	>100.0	31,505	>100.0	29,275	>100.0	27,487	>100.0
Green forages from arable land	100,323	50.39	102,398	48.71	102,750	43.26	100,580	43.87	107,360	42.43
Fodder roots	182	>100.0	195	>100.0	208	>100.0	207	>100.0	168	>100.0
Flowers and ornamental plants	30	>100.0	30	>100.0	30	>100.0	27	>100.0	25	>100.0
Orchards	14,678	>100.0	14,194	>100.0	14,190	>100.0	14,322	>100.0	12,113	>100.0
Surface of the greenhouses	46	>100.0	48	>100.0	34	>100.0	15	>100.0	14	>100.0
Arable land not cultivated	6,571	>100.0	4,704	>100.0	5,135	>100.0	4,636	>100.0	3,511	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure.

South-West Oltenia Region

In the South-West Oltenia Region, from the total of 1.45 million tons of cattle manure in 2017, only 1.05 million tons remained in 2021, the decrease being 27.4% per period (Figure 19).

The category of cows was also the main source in this area, with 74.2% and 73.3% participation respectively (Figure 20).

Fig. 19. The evolution of cattle manure production in the South-West Oltenia Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

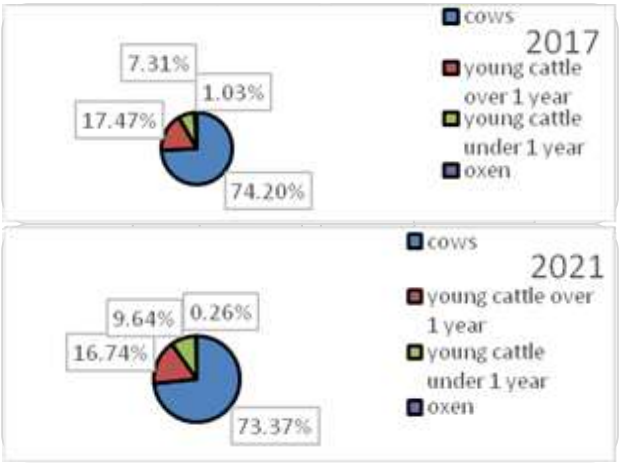

Fig. 20. The provenance structure of cattle manure in the South-West Oltenia Region
Source: Own calculations and graphing following MARD operational data [10].

Considering these developments, the amount of nitrogen decreased from 6.5 thousand tons in 2017 to 4.7 thousand tons in 2021 (Figure 21).

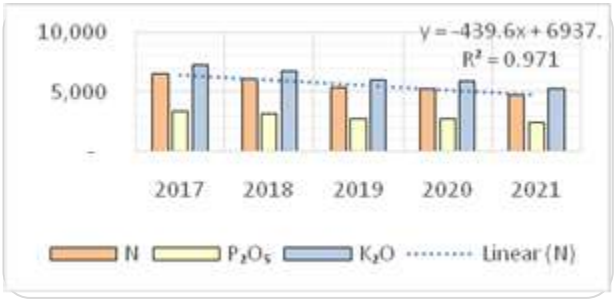

Fig. 21. The evolution of nutrient production from cattle manure in the South-West Oltenia Region (tons)
Source: Own calculations.

During the period 2017-2021, the surfaces cultivated in the South-West Oltenia Region remained approximately constant, at 1.13 million hectares. In this surface, the highest share was held by crops for grains, which are very well adapted to the soil and climate conditions in this part of the country (Table 8). The coverage potential with cattle manure was 100% for potatoes, or vegetables, or fruit orchards, or 78.3%, respectively 57.06% for green fodder from arable land.

Table 8. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in the South-West Oltenia Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	1,133,523	3.39	1,144,855	3.14	1,186,362	2.69	1,152,776	2.70	1,133,178	2.46
Cereals	816,332	4.71	822,223	4.37	833,352	3.82	837,868	3.71	780,482	3.58
Legumes	20,100	>100.0	23,248	>100.0	19,788	>100.0	24,773	>100.0	19,705	>100.0
Textile plants	:	0	50	>100.0	:	0	:	0	:	0
Oily plants	210,373	18.27	209,591	17.13	243,857	13.07	212,075	14.67	261,937	10.65
Medicinal and aromatic plants	36	>100.0	20	>100.0	34	>100.0	31	>100.0	460	>100.0
Potatoes - total	11,732	>100.0	12,199	>100.0	12,205	>100.0	6,961	>100.0	3,014	>100.0
Vegetables - total	35,506	>100.0	35,022	>100.0	34,685	91.89	28,280	>100.0	28,391	98.28
Green forages from arable land	49,088	78.32	51,983	69.06	51,740	61.60	53,331	58.35	48,905	57.06
Fodder roots	496	>100.0	509	>100.0	1,100	>100.0	507	>100.0	478	>100.0
Flowers and ornamental plants	3	>100.0	2	>100.0	3	>100.0	4	>100.0	5	>100.0
Orchards	26,469	>100.0	26,260	>100.0	26,135	>100.0	26,182	>100.0	26,863	>100.0
Surface of the greenhouses	51	>100.0	44	>100.0	43	>100.0	76	>100.0	60	>100.0
Arable land not cultivated	19,187	>100.0	16,772	>100.0	19,374	>100.0	16,770	>100.0	145,816	19.14

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

Bucharest-Ilfov Region

In Bucharest-Ilfov Region, the production of cattle manure decreased in the analyzed interval by 37.5% (Figure 22), up to the amount of 34.5 thousand tons.

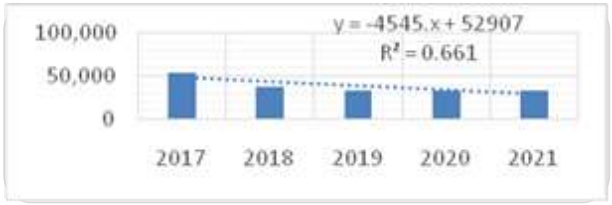

Fig. 22. The evolution of cattle manure production in Bucharest-Ilfov Region (tons)
Source: Own calculations and graphing following MARD operational data [10].

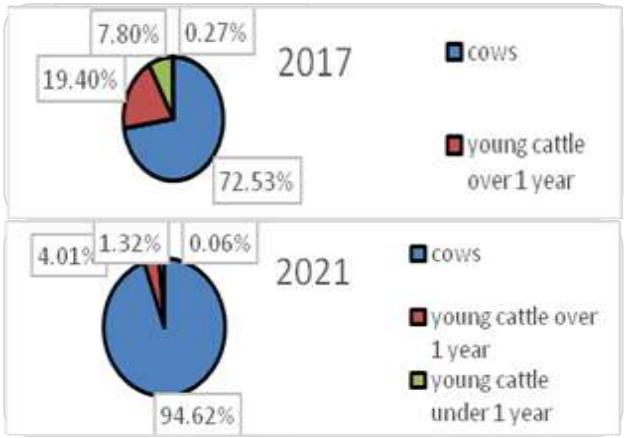

Fig. 23. The provenance structure of cattle manure in Bucharest-Ilfov Region
Source: Own calculations and graphing following MARD operational data [10].

Unlike the other regions, here the share of cows as a source of bovine manure has increased from 72.5% to 94.6%, which means that both the categories of bovine youth and that of oxen have been drastically reduced (Figure 23).
Following the decrease in manure production, the amounts of nutrients were reduced by 37.5%, nitrogen reaching an availability of 154 tons in this region (Figure 24).

Fig. 24. The evolution of nutrient production from cattle manure in Bucharest-Ilfov Region (tons)
Source: Own calculations.

The total cultivated area increased in 2021 by 11%, up to 73.9 thousand hectares. Of this, 58.5% was occupied with grains, and 30% with oil plants (Table 9). Even if the nutrient productions from cattle manure were reduced, considering the cultivated areas in this region, the areas with legumes, or those with fruit orchards, or greenhouses could be naturally fertilized from this species.

Table 9. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in Bucharest-Ilfov Region

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	66,530	2.18	66,829	1.54	63,561	1.43	62,315	1.46	73,893	1.22
Cereals	34,530	4.19	34,004	3.03	36,350	2.49	35,767	2.55	43,316	2.09
Legumes	1,334	>100.0	1,273	80.82	497	>100.0	589	>100.0	688	>100.0
Oily plants	21,877	6.61	22,898	4.49	18,205	4.98	17,964	5.07	22,181	4.08
Medicinal and aromatic plants	23	>100.0	23	>100.0	25	>100.0	25	>100.0	24	>100.0
Potatoes - total	468	>100.0	496	>100.0	496	>100.0	498	>100.0	25	>100.0
Vegetables - total	5,491	26.36	5,416	19.00	5,287	17.13	5,262	17.32	5,596	16.16
Green forages from arable land	4,926	29.38	4,943	20.81	4,825	18.77	4,855	18.77	4,766	18.97
Flowers and ornamental plants	76	>100.0	73	>100.0	60	>100.0	58	>100.0	71	>100.0
Orchards	448	>100.0	434	>100.0	425	>100.0	440	>100.0	282	>100.0
Surface of the greenhouses	49	>100.0	51	>100.0	43	>100.0	44	>100.0	116	>100.0
Arable land not cultivated	1,140	>100.0	1,035	99.40	1,201	75.42	863	>100.0	548	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure.

Total Romania

On total country, the amount of cattle manure was 16.7 million tons in 2017, respectively 15.3 million tons in 2021 (-8.5%) (Figure 25).

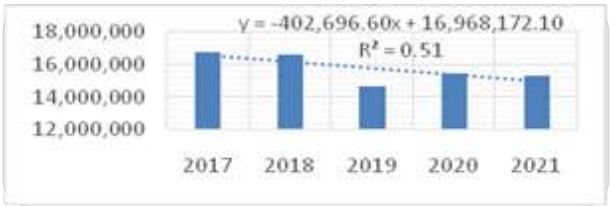

Fig. 25. The evolution of cattle manure production in Romania (tons)
Source: Own calculations and graphing following MARD operational data [10].

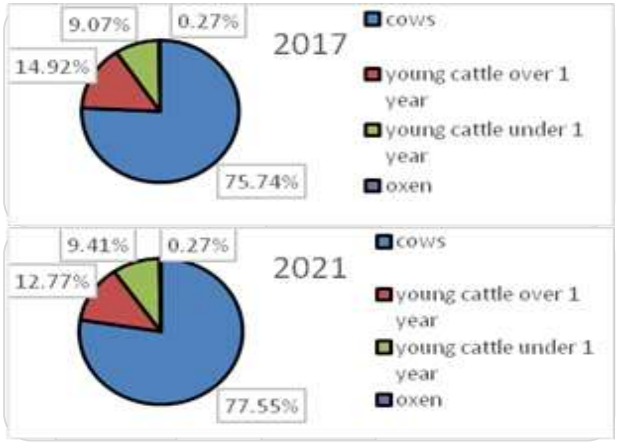

Fig. 26. The provenance structure of cattle manure in Romania
Source: Own calculations and graphing following MARD operational data [10].

The category of animals that mostly participated in the production of bovine manure was that of cows, with 75.7% in 2017, respectively 77.55% in 2021 (Figure 26).
The total amount of nutrients from bovine manure was 75.4 thousand tons of nitrogen in 2017, respectively 68.9 thousand tons in 2021, 38.5 thousand tons of phosphorus in 2017, respectively 35.2 thousand tons in 2021 and 83.7 thousand tons in 2017, respectively 76.6 thousand tons in 2021 (Figure 27).

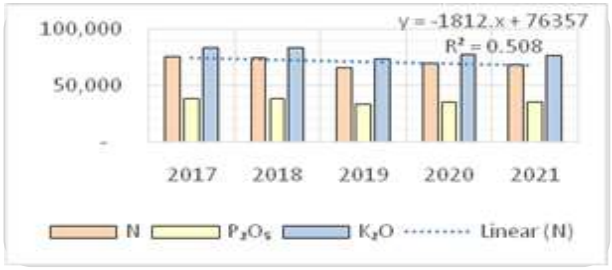

Fig. 27. The evolution of nutrient production from cattle manure in Romania (tons)
Source: Own calculations.

As indicated by the data in Table 10, Romania's cultivated area in 2021 was 8.26 million hectares, 0.5% less than in 2017.
The area cultivated with grains holds the largest share (64 .8% in 2021), followed by that with oil plants (20.7%).

Table 10. Surfaces cultivated (ha) and nitrogen fertilization potential from cattle manure, in Romania

Specification	***2017***	NFC, ***%***	***2018***	NFC, ***%***	***2019***	NFC, ***%***	***2020***	NFC, ***%***	***2021***	NFC, ***%***
Total	8,307,344	5.34	8,466,658	5.19	8,737,275	4.44	8,263,672	4.94	8,263,827	4.91
Cereals	5,192,340	8.54	5,257,168	8.36	5,569,090	6.97	5,338,067	7.65	5,351,547	7.58
Legumes	119,300	>100.0	133,408	>100.0	115,974	>100.0	107,443	>100.0	84,899	>100.0
Textile plants	1,688	>100.0	1,539	>100.0	1,433	>100.0	1,214	>100.0	729	>100.0
Oily plants	1,766,340	25.11	1,815,002	24.22	1,800,132	21.57	1,678,832	24.34	1,715,354	23.66
Medicinal and aromatic plants	3,193	>100.0	1,781	>100.0	1,745	>100.0	1,759	>100.0	2,677	>100.0
Potatoes - total	167,424	>100.0	169,304	>100.0	170,063	>100.0	98,498	>100.0	84,402	>100.0
Vegetables - total	224,571	>100.0	226,328	>100.0	227,720	>100.0	200,501	>100.0	197,677	>100.0
Green forages from arable land	874,653	50.71	907,250	48.46	900,979	43.10	886,857	46.07	880,737	46.07
Fodder roots	10,353	>100.0	10,051	>100.0	10,641	>100.0	10,127	>100.0	6,316	>100.0
Flowers and ornamental plants	310	>100.0	312	>100.0	317	>100.0	278	>100.0	345	>100.0
Orchards	138,999	>100.0	137,263	>100.0	135,102	>100.0	135,991	>100.0	137,617	>100.0
Surface of the greenhouses	250	>100.0	233	>100.0	206	>100.0	207	>100.0	242	>100.0
Arable land not cultivated	235,918	>100.0	218,968	>100.0	229,034	>100.0	219,183	>100.0	323,908	>100.0

Source: National Institute of Statistics – Tempo online [11].
*NFC – Nitrogen fertilization potential from cattle manure

The amounts of nutrients from cattle manure could cover 5.34% of the total cultivated area at country level in 2017, respectively 4.91% in 2021. Another option - 8.54% of the total area with cereals, in 2017, respectively 7.58% in 2021.
In proportion of 100%, it would have been possible to fertilize the areas cultivated with legumes, or those with potatoes, or with vegetables, or orchards for fruit.

CONCLUSIONS

In the current economic, social and environmental context in which agricultural activities are carried out, debates regarding environmental protection, or factors with a positive or negative influence on the environment and climate include topics related to the involving of the bovine species. Assuming the theoretical and estimated

limitations, the work is written as an argument in favour of the contribution that the bovine species has, as a supplier of natural and sustainable fertility for the soil, of course, under the conditions of a proper management of nutrients. The practice of different agricultural systems has demonstrated that nature creates and regenerates itself, with the support, of course, of man, who, through the sustainable measures he undertakes, can reset the balance in agricultural activities.

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REFERENCES

[1]Aiysha, D., Latif, Z., 2019, Insights of organic fertilizer micro flora of bovine manure and their useful potentials in sustainable agriculture. PLoS ONE 14(12): e0226155. https://doi.org/10.1371/journal.pone.0226155. Accessed on January 27, 2024.

[2]Du, Y., Cui, B., Zhang, Q., Wang, Z., Sun, J., Niu, W., 2020, Effects of manure fertilizer on crop yield and soil properties in China: A meta-analysis, *CATENA*, Vol. 193, 104617, https://doi.org/10.1016/j.catena.2020.104617. https://www.sciencedirect.com/science/article/pii/S0341816220301673). Accessed on January 27, 2024.

[3]Faissal, A., Ouazzani, N., Parrado, J.R., Dary, M., Manyani, H., Morgado, B.R., Barragán, M.D., Mandi, L., 2017, Impact of fertilization by natural manure on the microbial quality of soil: Molecular approach, Saudi Journal of Biological Sciences, Vol. 24(6), 1437-1443, https://doi.org/10.1016/j.sjbs.2017.01.005. https://www.sciencedirect.com/science/article/pii/S1319562X17300050. Accessed on January 25, 2024.

[4]Gil, M.V., Carballo, M.T., Calvo, L.F., 2008, Fertilization of maize with compost from cattle manure supplemented with additional mineral nutrients, Waste Management, Vol. 28(8), 1432-1440, https://doi.org/10.1016/j.wasman.2007.05.009. https://www.sciencedirect.com/science/article/pii/S0956053X07001717. Accessed on January 27, 2024.

[5]Guo, Z., Zhang, J., Fan, J., Yang, X., Yi, Y., Han, X., Wang, D., Zhu, P., Peng, X., 2019, Does animal manure application improve soil aggregation? Insights from nine long-term fertilization experiments, Science of The Total Environment, Vol. 660, 1029-1037, https://doi.org/10.1016/j.scitotenv.2019.01.051. https://www.sciencedirect.com/science/article/pii/S0048969719300579). Accessed on January 26, 2024.

[6]Hollas, C.E., Rodrigues, H.C., Oyadomari, V.M.A., Bolsan, A.C., Venturin, B., Bonassa, G., Tapparo, D.C., Abilhoa, H.C.Z., da Silva, J.F.F., Michelon, W., Cavaler, J.P., Goldschmidt Antes, F., Steinmetz, R.L.M., Treichel, H., Kunz, A.,2022, The potential of animal manure management pathways toward a circular economy: a bibliometric analysis. Environ Sci Pollut Res 29, 73599–73621. https://doi.org/10.1007/s11356-022-22799-y. Accessed on January 27, 2024.

[7]Leah, T., 2015, Prospects of using the local organic waste in the agriculture of the Republic of Moldova. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 15(1), 259-264. https://managementjournal.usamv.ro/pdf/vol.XV_1/Art37.pdf, Accessed on January 10, 2024.

[8]Li, Q., Wagan, S.A., Wang, Y., 2021, An analysis on determinants of farmers' willingness for resource utilization of livestock manure, Waste Management, Vol. 120, 708-715, https://doi.org/10.1016/j.wasman.2020.10.036. https://www.sciencedirect.com/science/article/pii/S0956053X20306073. Accessed on January 27, 2024.

[9]Maia, A. H., de Souza, M. E., da Silva, F. C., Rebelatto, B. F., Silva, T. O., Souza, V. S., Ferreira, L. S., 2018, Productivity of radish fertilized with different doses of bovine manure. African Journal of Agricultural Research, 13(18), 963-968. https://doi.org/10.5897/AJAR2018.13140. Accessed on January 27, 2024.

[10]Ministry of Agriculture and Rural Development, MARD, www.madr.ro, Accessed on Jan. 5, 2024.

[11]National Institute of Statistics, Tempo online, www.insse.ro, Accessed on Jan. 5, 2024.

[12]Nett, L., Averesch, S., Ruppel, S., Ruhlmann, J., Feller, C., George, E., Fink, M., 2010, Does long-term farmyard manure fertilization affect short-term nitrogen mineralization from farmyard manure? Biol Fertil Soils 46, 159–167. https://doi.org/10.1007/s00374-009-0416-5. Accessed on January 26, 2024.

[13]Simionescu, V.M., Rusu, M., Bulica, I., 2016, Importance of systematic fertilization with mineral and organic fertilizers for preserving and increasing soil fertility. Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development", Vol. 16(1), 487-492. https://managementjournal.usamv.ro/pdf/vol.16_1/Art76.pdf, Accessed on January 10, 2024.

[14]Zavattaro, L., Bechini, L., Grignani, C., van Evert, F.K., Mallast, J., Spiegel, H., Sandén, T., Pecio, A., Giráldez Cervera, J.V., Guzmán, G., Vanderlinden, K., D'Hose, T., Ruysschaert, G., ten Berge, H.F.M., 2017, Agronomic effects of bovine manure: A review of long-term European field experiments, European Journal of Agronomy, Vol. 90, 127-138. https://doi.org/10.1016/j.eja.2017.07.010. https://www.sciencedirect.com/science/article/pii/S1161030117301041). Accessed on January 27, 2024.